NOTES ON THE BIOLOGY AND SOCIAL LIFE OF EUPONERA GILVA ROGER VAR. HARNEDI M. R. SMITH

BY CARYL PARKER HASKINS

Because of the great kindness of Dr. M. R. Smith in generously giving to the writer living colonies of the ant *Euponera gilva* var. *harnedi* (Ponerinæ, Ponerii) described by him in a recent number of the "Annals" of the American Entomological Society, it has been possible to subject living colonies of this highly interesting insect to daily observation for more than a year. Innumerable problems of biology and social behavior, both common to the Ponerinæ in general and peculiar to the species, still await solution, and the material which is presented here can be considered as nothing more than the result of the most superficial investigation. Nevertheless it is considered, because of the historic background of the species, its peculiar nature, and its unusual adaptability to artificial environments, that sufficient data has accumulated to be worthy of brief delineation at the present time, in the hope that it may be of some interest to those concerned with the Ponerinæ of North America.

SOCIAL HABITS

The colonies of *E. harnedi*, in common with those of most other species of Ponerinæ, tend to be restricted to rather small size, but this is far less true of the present species, and perhaps of the Ponerii in general, than of several other tribes. In Mississippi, where the ant has been especially studied by Dr. Smith, from whom all information concerning the species under natural conditions has been derived, the formicaries are excavated by preference in rotten logs and stumps in woodland areas. Unquestionably the ant is very largely hypogeaic in habit, but that it is strictly so may be questioned. Under artificial conditions individuals have shown both inclination and ability to emerge from artificial earth-containing nests to forage, later returning to their formicaries through a narrow opening, which was readily located. Provender placed at some distance was successfully secured and brought within in a short time. It is believed that under normal conditions the ants maintain a few open galleries, carefully concealed, from which they may emerge to forage along moist wood surfaces, returning in a very short time, much in the fashion that *Ponera coarctata* workers forage along moist ground. At the time of the liberation of the winged forms this tendency becomes exaggerated. In the artificial nest a crater was built about the entrance at such time, punctured throughout with galleries, and the winged forms, together with a large number of workers, massed directly beneath it for several days.

Males and perfect females are produced in Mississippi during the months of May and June, and colonies kept artificially in Connecticut and New York produced them at the same time. The males are fully pigmented when hatched, and the wings are fully expanded, though soft and not folded, on emergence from the cocoon. They are rather helpless, however, but become fully matured and active within eight hours, and show an inclination to leave the nest when about four days old. The females are hatched with soft but fully-expanded wings, the pupal skin having been shed within the cocoon, and bearing the pale lemon-yellow coloration of the callow workers. Full adult coloration was assumed in the specimens observed in from eight to twelve days.

It is believed that a true nuptial flight occurs, but this has not been observed. The winged females matured in the artificial nest showed a desire to leave within two weeks after hatching, but being accidentally prevented from so doing, cast their wings within the nest when from nineteen to twenty-seven days old, and remained with the parent colony. Almost certainly this procedure was an aberration induced by artificial conditions. It is precisely similar to the action of young females of the genera *Ponera* and *Stigmatomma,* which normally emerge, under artificial conditions. In all probability the nuptial flight of *E. harnedi* is conducted as with *Ponera* and *Stigmatomma,* where the young queens, for the most part resting on the ground or on low vegetation near the nest-entrance, are fertilized by the active, low-flying males.

No data has been obtained on the action of the young queen after fertilization. The usual presence of supernumary queens in wild colonies would indicate that as a rule the winged females return to the parent colony, which multiplies by division. These supernumary females are sometimes very plentiful. One colony generously given by Dr. Smith contained no less than ten such queens associated with some sixty workers. It was readily split, and the resulting colonies, each with a single queen, continued to develop without difficulty. It is an interesting fact that supernumary queens, if isolated from the workers about them, are often hostile, indicating the possibility that alien females may sometimes be adopted.

On the other hand, fertile females if isolated clearly show the instinct of colony foundation in the fashion employed by higher ants, and at least one female voluntarily isolated herself. In the presence of a complete lack of direct evidence, it may be tentatively considered that, while the majority of young females are fertilized near their own formicaries and return to them, a few fly actively and establish independent communities.

The relations between adults in colonies of *E. harnedi* are in general rather simple, but show certain curious complexities. Distribution of ingluvial food from worker to worker rarely takes place under normal conditions, due to the eminently entomophagous nature of the species, yet it is believed that both the instinct and the ability are present. To test this, a drop of honey was fed to a colony which for a long period had been fed only on the larvæ of higher ants. Several workers imbibed it after some hesitation, and returned to the brood chamber. Here they were beset by a cordon of sisters, actively soliciting food with the forefeet and mandibles. Most of these were ignored, but one was finally accepted. After soliciting a moment this seeker became rigid, and eagerly licked the tongue of the full-fed individual. This was continued without interruption or further solicitation for half a minute, when the solicitor broke away and hurried off at once. No drop was seen to pass between the individuals, but the impression that feeding by regurgitation actually had taken place was very strong indeed. Moreover, a young callow, two days old, was present in the brood-chamber and solicited actively. Within an hour its crop was filled, and it is hardly likely that it would have fed of its own accord without the interior of the nest.

Deportation is practiced extensively and skillfully. Workers or perfect females are seized by the mandibles and dragged forward, their captors running backward. Old queens and callow queens and workers are deported most frequently when the nest is disturbed, but adult workers are often given similar treatment. Males are seized most frequently by the antennæ, sometimes by the lateral margins of the small head, and deported in similar fashion.

Communication of a rudimentary sort is effected readily among workers, but, as it is both less perfect than that among higher ants and has not been as carefully experimentally tested, little may be said of it. Many of the usual modes employed by higher ants are present, notably divarication of the mandibles and extensive use of the antennæ and forefeet, especially in the solicitation of nourishment. Stridulation has not been observed with sufficient certainty to be affirmed, but it is believed, for reasons later to be given, that it is used, though with less precision than among the Myrmicinæ.

The range of acceptable alimentary substances is much greater with *E. harnedi* than among many hypogeaic Ponerinæ, and the rather adaptable nature of the species is shown in the readiness with which new food sources are recognized and exploited. Meat, fruit, and honey are all readily accepted, though rarely fed to the larvæ, and a wide range insect food is taken. In the artificial nest houseflies, queens and workers of *Termes flavipes,* and larvæ and pupæ of the ants *Camponotus novaboracensis, C. americanus, Lasius americanus, Acanthomyops claviger, Formica subsericea, Cremastogaster lineolata,* and *Leptothorax longispinosus* have all sustained colonies for long periods.

The nest-form of the species is rather highly developed. Large and definite brood-chambers are maintained, smoothly finished and kept entirely distinct from the galleries, which are long and tenuous, but well-made. Compact kitchen-middens are maintained, usually near the nest-entrance, and no foreign material is tolerated within the interior of the formicary. Unused food particles, empty cocoons, pupal excuviæ, and dead adults are brought at once to the refuse-pile and there discarded. Workers tend to die, from whatever cause, in the interior of the nest rather than outside as with *Stigmatomma pallipes,* and are dragged immediately, often before they have hardened, to the middens. If the entrance to the artificial nest be opened, the refuse is carried from the pile and cast outside within a short time.

Young queens and males, after they have matured, receive no more attention within the nest than workers, except that males receive the treatment accorded immature forms when the nest is disturbed. Fertile females are given somewhat more attention than workers, but no more than their greater size and power would warrant. When the nest is disturbed they are deported more often than workers. They move freely about the formicaries without attendants, feeding directly on food which they encounter. They participate in every function of the nest except foraging, caring for the young as competently as the workers, even in large colonies, and often assisting in excavation of galleries.

Development of Brood, Relations Between Adults and Brood

The fertility of the queens of *E. harnedi* is unusually high. A single queen, living under the handicap of artificial conditions, reared to the pupal stage seventy-six young in the course of sixteen months, and the number of eggs which were laid and devoured or which perished must have been nearly half as great. This is rather surprising in view of the fact that the eggs are unusually large relative to the parent insect. The queens measure in the neighborhood of .600 cm., while the longer axis of the egg measures not far from .125 cm. When timed in the height of the laying season, this queen was observed to lay seventeen eggs between February 28 and March 22, 1929, an average of .773 eggs per day.

Shortly after being laid, the eggs, rendered adherent by their coating of saliva, are brought together in packets of twenty or more, and allowed to lie on the floors of the brood-chambers. It is difficult to determine accurately the lengths of incubation periods for more than a few ova unless numerous colonies are at hand, since when many eggs are present determination of the identity of any given specimen becomes practically impossible. But four determinations, therefore, have been made which are considered worthy of record. These eggs hatched respectively in 31, 30, 30, and 31 days at a mean temperature of about 23° C.

Immediately upon hatching the larva is removed from the egg-mass and allowed to lie singly on the chamber floor. Not infrequently the ova and hatched larvæ are kept in separate chambers, and a rough division of the larval brood according to size is usual, but not rigidly maintained. The larvæ are fed with bits of solid food in the usual Ponerine fashion, and are active and athletic, and wholly entomophagous. They are surprisingly sensitive. Not infrequently, when food was introduced at the entrance to an artificial nest, larvæ uncurled and stretched their long necks in search of it. It is possible that this action resulted from an association of light, perceived through the general integument, with the fact of food as previously experienced.

The adults of the colony spend much time in licking the larvæ for exudates and also apparently for saliva. This food, indeed, seems normally to constitute the entire diet of the callows for the first few days. The adults frequently pinch the larvæ vigorously about the neck and abdomen, apparently to hasten and encourage .he flow of exudates.

When mature, the larvæ are carefully covered entirely with earth in the usual manner, and spin at once. The earth is removed as soon as the first sheet of silk is completed, and the cocoon is cleaned within a short time. The entire process has been seen completed within nineteen hours. Within two days a well-defined meconium spot appears. The developmental periods observed for larvæ, from the time of hatching to the time of cocoon-spinning, were 21, 22, 25 ,33 days, varying with the temperature and particularly with the feeding. The time for the appearance of the reconium was observed as 1, 2, 2, 1, 2 days. In one case a larva not ready to spin was seen covered with earth. It was left in this condition for five days, when it perished, and the earth was removed on the following day. It is rather doubtful whether this situation ever arises under normal conditions, but it is believed that the reverse condition, which often occurs in the artificial nest, may sometimes take place normally. This is the failure to cover larvæ ready to spin. Under artificial conditions the larvæ so treated transform to naked semipupæ and are then usually destroyed. The writer, however, has taken a perfect naked pupa from a wild colony of *Ponera coarctata*.

The cocoons of queens and males are somewhat larger than those of workers, and the latter are somewhat more baggy, at least in some cases, but it is practically impossible to distinguish the larvæ of the perfect forms, even when fully matured. The specimens observed, however, were reared in the artificial nest, and tended to nanism on this account. This may well not be true under normal conditions. The duration of the pupal stage differs little from queen to worker. The observed periods were 31, 32, 31, 31, 33, and 33 days. The period spent in the cocoon by an observed developing male was 36 days.

It is believed that the young adults of *Euponera harnedi* are able to emerge from the cocoon without assistance, but this has not been tested. A hatching cocoon is usually surrounded by a number of workers, biting and tearing at the anterior pole. The cocoon is sometimes opened by their efforts, but usually by those of the young callow. Eclosion is usually rapid, becoming complete in half an hour, but may take much more time. In one observed case nearly twelve hours was required. The entire head of the callow is eagerly licked by the attendants as soon as it appears, and often the young insect is dragged from the cocoon, laid with the ventral side up, and licked and pinched exactly as though it were a larva. Substantially the same treatment is accorded perfect females and males. For a day the young queens and workers are very helpless, and remain quietly in the brood-chamber. Thereafter they take an active part in the colony, though they usually remain in its interior for a few days. They forage, however, long before having assumed full adult coloration. The duration of the callow stage has been observed as 14, 19, 17, 21 days for workers, and for queens, 12 and 8 days. The period at which full adult coloration is assumed is difficult to estimate with any degree of accuracy, and false estimations probably account for the irregularities of these figures. The eyes of the callow females are fully pigmented on emerging, and are conspicuous against the uniform pale yellow coloration of the body.

SIGHT

Except in the male, the sense of sight is poor with *E. harnedi,* as would be expected of a hypogeaic ant, but the eyes are far from useless. Darkened squares placed over the glass pane of the artificial nest quickly attract the ants, and the brood is shortly transferred beneath them.

Through the great kindness of Dr. Erwin Burr Kelsey and Mr. Eugene Marchand of Sterling Chemistry Laboratory, Yale University, it was possible to set up an earth-containing nest of *E. harnedi* in a darkened laboratory in the field of a solar spectrum. This spectrum was produced by the diffraction of a beam of light from a carbon arc, passed through a condensing lens and a carbon disulfide-glass prism and was so arranged that it was exactly adjustable to the size of the nest used. It was thus possible to limit the choice of the ants to the humanly visible spectrum, and eliminate an unknown but very gross error of absorption caused by the action of the absorption curves of CS_2, very steep in the ultra-violet, and of several types of glass. The nest contained two queens, twenty-five workers, and ten larvæ.

The experiment was begun at 2:30 P. M. At this time the ants were generally distributed throughout the nest. At 2:36 a concentration was apparent in the green region, which shortly shifted toward the red. One queen proceeded to the red, followed by several workers, one of which was deported by a sister. The other queen, with several workers, migrated to the extreme violet. Thereafter, at the times indicated, the concentrations were as follows:

Time	Red	Yellow	Green	Blue	Near Violet	Far Violet
3:30	1 ♀, 7 ☿	0	0	3 ☿	0	1 ♀, 11 ☿

The spectrum was suddenly reversed. There was an immediate movement from the end now violet toward that now red, and *vice versa.* All seven workers formerly in the red started at once toward that color.

Time	Red	Yellow	Green	Blue	Near Violet	Far Violet
3:10	1 ♀, 8 ☿	0	2 ☿	4 ☿	0	1 ♀, 11 ☿
3:14	1 ♀, 7 ☿	0	0 ☿	6 ☿	0	1 ♀, 10 ☿

A larva was seen carried into the red, where most of the larvæ were collected, at 3:11. It was later returned to the green. The spectrum was again reversed. The reversal was marked by prompt and vigorous efforts of the ants to follow the change of colors, the movement being most noticeable at each end.

Time	Red	Yellow	Green	Blue	Near Violet	Far Violet
3:19	1 ♀, 9 ☿	0	0	1 ☿	1 ♀, 9 ☿	6 ☿

The spectrum was then removed and the ants left in darkness until 3:25, when the colors were again flashed on.

Time	Red	Yellow	Green	Blue	Near Violet	Far Violet
3:30	1 ♀, 4 ☿	0	1 ☿	1 ♀, 3 ☿	7 ☿	10 ☿

The queen in the blue was, when observed, being deported toward the red by one of the three workers.

It is unfortunate that in certain recordings not all the workers present could be located, because of the very dim light which could be permitted for observation without materially changing light conditions in the nest. For the same reason, it cannot be affirmed that the individuals were the same at the red and violet ends after each reversal of color, but it is certain that there was a movement tending toward that condition. Though poorly controlled and rough, it has seemed to the writer that this experiment indicated rather markedly an ability of *E. harnedi* to differentiate delicately between light intensities, if not to distinguish colors. What the relative intensities of the colors were cannot be determined, due to the irregular shape of the CS_2 prism and ignorance of the absorption-curves of the arc-lamp lens.

To eliminate the physical factor of differing light intensities, resort was had to the Wratten color filters manufactured by the Eastman Kodak Company. Filters No. 48A and No. 70

were selected for the purpose. Each of these transmits 0.6 per cent. of incident white light, but their range of greatest transmission is very different, No. 48A passing 0.31 per cent. of incident light of wave-length 510 mμ, and 8.2 per cent. at 400 mμ, with a maximum of 27.1 per cent. at 450 mμ, while No. 70 allows 1.0 per cent. to pass at 650 mμ, and 74.5 per cent. at 700 mμ. The one, of course, is red in coloration, the other, a rich blue. There is no physical change of light intensity in passing from one to the other.

A modified Lubbock nest, earth-containing, was set up, consisting of two chambers just of sufficient size to be completely covered by the filters, with a narrow passage between. To test the power of color detection of queens in particular, eight queens from a single colony were introduced, with 24 larvæ, at 1:15 P. M. Mar. 15. The filters were placed over the nest, and it was exposed to intermittent sunshine, at 1:28, with 4 queens and 8 larvæ initially under the red, and 4 queens and 16 larvæ under the blue. The results were these.

Time	Number under red	Number under blue
2:01	3 queens, 8 larvæ	5 queens, 16 larvæ
2:38	3 queens, 16 larvæ	5 queens, 8 larvæ

Though from the same colony, these queens were violently hostile, and enmity and fear of the new surroundings probably rendered the results void of significance. All but one of the queens were removed, and twenty workers introduced. The nest was exposed at 3:02. The queen was then in the passage between the colors, and the workers about evenly distributed between them.

3:58	Queen, 5 workers	15 workers
	Colors reversed at 4:03	
4:23	Queen, 13 workers	7 workers

The results showed how thoroughly fear and unfamiliarity with new surroundings could nullify the value of such experiments. The nest was accordingly left quiet and in total darkness until March 11, at which time it had become well-established, with a good system of chambers and galleries in both portions of the nest, and larvæ contained in each half. At that time a test was made with a tungsten-filament 23 watt Mazda lamp with reflector at a distance of about 6 cm. used as the source of illumination and Wratten filters No. 78, used merely to screen the light to daylight quality, were superimposed on the color screens. The colony was exposed at 9:03 P. M., at which time 11 larvæ lay in the red, 7 in the blue, and workers were passing rapidly between the two chambers, being about equally distributed. Several larvæ had perished in the interim.

9:20	3 workers, 7 larvæ	Queen, 17 workers, 11 larvæ.

Ten workers and three larvæ were then left in the nest; and it was kept in darkness until March 19. It was fed during this time. On March 19 it was exposed to sunshine, the screening filters being omitted, at 3:21 P. M., at which time 5 workers were under the red and five under the blue.

3:40	5 workers	5 workers	Case I
	Colors reversed		
3:54	7 workers	3 workers	Case II
	Colors reversed		
4:24	1 worker	9 workers	Case III
	Colors reversed		
4:44	6 workers	4 workers	Case IV
	Colors reversed. The electric light, with screening filters, introduced		
5:01	0	10 workers	Case V
	Colors reversed		
5:23	10 workers	0	Case VI

In case I, the ants were indifferent. In case II, 2 ants passed from blue to red, in case III, 2 passed from red to blue, in case IV, 3 passed from red to blue; in case V, 4 passed from red to blue, in case VI the ants were indifferent. In four of the six cases the reversal of colors was followed by a movement of several individuals to follow the color to which they had become accustomed, but no color preference was to be seen.

In the hope that a color-preference general for the species might appear in colonies longer and better established, a colony was next used which had occupied the same quarters—a nest six by eight inches square—for eleven months. Two brood-chambers, one containing 13 cocoons, 3 large larvæ and a good-sized egg packet, and the other a mixed lot of some 25 larvæ, were covered respectively with the red and blue filters, and the colony exposed to sunlight at 1:37 P. M. on November 20, 1929. At 2:15 one larva had been moved from the blue to the red. At 3:05 nothing further had occurred. The same experiment was repeated on December 30, 13 cocoons, 3 large larvæ, 6 small larvæ and eggs being covered in this case by the blue, and 16 larvæ being covered by the red. The colony was exposed at 1:25. At 1:43 every larva had been taken from the red, and either piled outside in full sunlight, or under the blue. It is not believed that a heat effect was responsible for this behavior, since some care was used to exclude it.

On January 26 the expedient was tried with the same colony of leaving the greater portion of it in sunlight initially, and using the filters as refuges. The nest was exposed at 1:24, at which time but one worker and a cocoon were under the red, and nothing was under the blue. At 1:40 the greater portion of the colony was still in full sunlight, but larvæ were being carried under the red, where several had accumulated. At 1:52 larvæ were being actively transferred from the red to the blue. The queen and a large number of workers next congregated under the blue, but at 1:57 only a cocoon and a larva remained under the blue, and nothing was under the red. The ants had returned to full sunshine. The colony used in all this work consisted of a queen, some sixty workers, nearly all of which had matured from eggs laid within the nest, and a hundred or more young.

No conclusion has been drawn from these experiments. Extension and more rigid control may result in the attainment of more definite results. The writer believes that they do indicate, however, a clear ability on the part of *E. harnedi* to differentiate from color to color within the visible human range, but it cannot be shown whether this is due to a true perception of color, or to a mere delicate distinction of light intensities. Although in the second series the factor of varying physical light intensity was controlled, it may be readily argued that one color, lying much nearer to the limits of light-sensitivity of the ants than the other, would appear the darker to them. Nothing whatever is shown as to the limits of the visible spectrum for *E. harnedi,* since the preference for red or blue, though sometimes quite constant for the individual, becomes widely variant among large numbers of ants.

HEARING

Because of the generous advice and suggestions of Dr. Alan Tower Waterman of Sloane Physics Laboratory, Yale University, the writer has been enabled to conduct experiments which have thoroughly convinced him of the ability of *E. harnedi* to perceive vibrations transmitted through the air. As yet, they have given no indication of the limitations of this auditory power.

Considerable precaution was used, in conducting this work, to eliminate mechanical vibration, so readily perceived by all ants. Thirty-two layers of soft toweling, surmounted by a rubber sponge, were placed on a light cloth-covered table, and this insulating stand was used as a base for the tested colony.

As an indication of the state of vibration existing in the panes of glass forming the floor and the roof of the nest, a wire indicator was fastened with sealing-wax to the upper pane very near to the brood-chamber of the ants. This indicator consisted of an effective length of 15 cm. of extremely light and stiff wire, to which was attached a very light mirror, made by plating a circular microscope slide-cover with a thin coating of silver. The weight of the wire and glass together was 0.25775 ± 0.00005 gm. A beam of light supplied by a tungsten-filament Mazda lamp was allowed to fall on the mirror, and the reflected ray was focused by means of a condensing lens on a distant wall. Such an arrangement is capable of detecting rather minute vibrations, and through the kindness and interest of Frances Parker Haskins, it was possible to keep the spot of light from the mirror under continuous and independent observation.

The range of resonance of the wire-glass system itself can be calculated by use of Young's modulus. Experimentally the fact was determined that the wire did not resonate to sounds of the pitches used, which were all included between low and high C. It was therefore established that any vibrations observed were due to vibrations of the nest itself. Whether these were due to resonance or to mechanical shock was of course immaterial. It proved impossible to eliminate a slight constant vibration of the wire, but to this the ants paid no attention, and there was no sharp increment of vibration when a pitch was sounded, sufficient to account for the actions of the ants.

The reactions of the ants were often quite striking. Several individuals, and sometimes all those within the field of observation, would simultaneously start forward at the sounding of the pitch, for the production of which a pitch-pipe was used. Frequently larvæ were dragged hurriedly away at once, and very often the ants snapped at one another or at the walls of the chamber in which they were resting. This effect was best seen when an ant was entirely at rest, and the vigorous start which the sudden sound produced left the writer in no doubt that it had been perceived. Individuals varied greatly in the degree of their visible reaction, which, of course, is no indication of a varying power of perception. All tended to become rather readily used to the sudden noise, and often ceased to respond satisfactorily after a few notes. For this reason the tests were begun at the higher end of the scale for certain colonies and at the lower for others. Seven colonies were tested, with the results indicated below. When a reaction to the sound was satisfactory, the fact is indicated by a + sign, when unsatisfactory or negative, by a – .

Colony	C	C	D	D	E	F	F	G	G	A	B♭	B	C	
1	+	+	+	+	+	+	+	+	+	+	+	+	+	Begun low
2	+	+	+	+	+	+	–	+	+	–	+	+	–	Begun high
3	+	+	+	–	–	+	+	+	+	+	+	–	+	Begun low
4	–	–	+	–	–	+	+	+	–	–	+	–	+	Begun high
5	+	–	+	+	+	+	+	+	+	+	–	+	+	Begun low
6	–	–	–	–	–	–	+	–	–	+	+	+	+	Begun high
7	+	+	+	+	+	+	+	+	–	+	+	+	–	Begun low

A male was present in colony 1, and a special series of tests was made on it when 13 days old, but not the least response could be obtained, though the queen and workers of the colony were much agitated, for sound of any pitch. It is believed that this may, incidentally, constitute some evidence for the successful exclusion of mechanical vibration, since the same insect was very sensitive to such disturbance.

Colony 1 had been fed 2 days previous to the test, colony 2, 6 days previously, colony 3, the previous night, colony 4, the previous night, colony 5, 6 days previously, colony 6, 6 days previously, colony 7, 6 days previously. No great difference was to be seen between the sensitiveness of queens and workers. In colony 1 the old queen was very slightly less sensitive than the workers. Young queens were quite markedly unresponsive. In colony 2, the brood-queen was more sensitive than the workers, and the same was true in colony 7.

A considerable difference in responsiveness is to be seen to differently pitched notes, which was fairly consistent. Thus three nests showed unresponsiveness to the pitches of C, D, E, and G, two to C, A, B, and C, and one to D, F, F, G, and B^b. No pitch was responded to by less than three colonies, indicating rather considerable powers of perception within this range, a fact rather surprising to the writer.

SMELL, TASTE, TOUCH

That the sense of smell is well developed is indicated by the rapidity with which food placed at a distance is sensed and the accuracy with which its position is located, together with the facility with which alien individuals of the same species are detected. The sense of taste is present and rather delicate, as evidenced by the discrimination used in bringing in apparently acceptable food materials after they have been sampled. The slight touch or jar which is required to startle an inert individual is sufficient evidence of the delicacy of the generally distrbuted tactile sense.